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EVALUATION OF SOLAR DRYER
FOR DRYING WATER HYACINTHS

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INTRODUCTION

A solar dryer was built especially to test the feasibility of drying water hyacinth to approximately 15 percent water content for use as a protein additive for cattle feed. Other research has been done with water hyacinth on determining its value as a cattle food, on harvesting, on producing methane, on its usefulness for removing pollutants from water, on its growth rate, etc., and these are all reported elsewhere.

The objectives of this experiment were to:

1. Determine the feasibility of using solar energy to dry water hyacinth to 15 percent water content in Southern Mississippi at the NASA/NSTL.

2. Evaluate a simple solar collector design using air as the transfer media and without heat storage.

3. Determine the ratio of solar energy to commercial electrical energy in a facility of this type using electric powered fans to move the air for drying.

MATERIALS AND METHODS

The dryer consists of the following systems:

1. Solar Collectors - 1152 square feet of flat plate, nonadjustable, nontracking, single glass, wood construction, galvanized sheet metal with flat black paint on top side. Twelve thousand cfm of ambient air is pulled across under the black body and carried through insulated ducts to the dryer where it is introduced above the plant material to be dried.

2. The Dryer Housing contains 2304 square feet of floor space (see Figures 1 and 2) with raised grating over an air plenum. The walls and roof are corregated fiber glass to admit solar energy and reject rain. There are six fans of 6500 cfm each which draw air down through the plants being dried and through the grating and exhaust it to the outside. The fans are controlled by a humidistat so as not to run when the available ambient air is too moist to be of drying quality.

3. Instrumentation -

    a. A kilowatt hour meter to determine the amount of commercial electricity consumed.

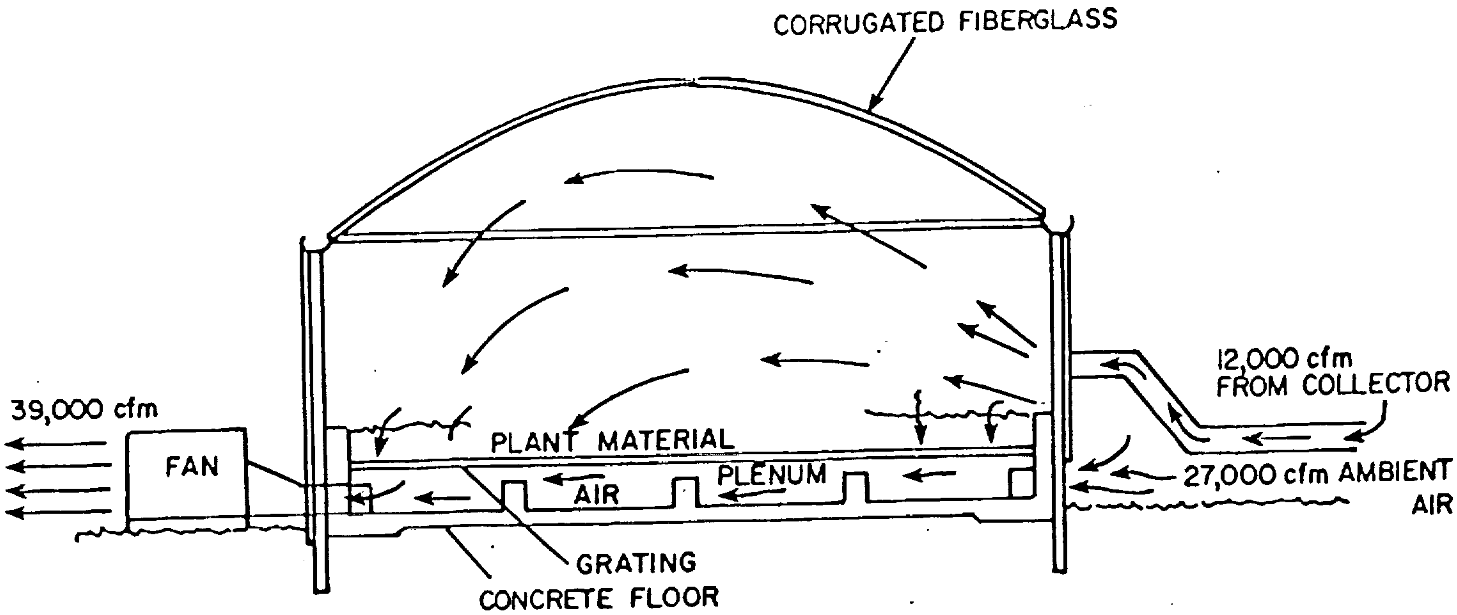

Figure 2. Standard Greenhouse Field Assembled

b. Two hygrothermographs to record the dry bulb temperature and relative humidity both ambient and inside the dryer.

c. A twelve point recorder to provide ambient dry-bulb temperature, ambient dew-point temperature, black body temperature, collector outlet air temperature, dryer dry-bulb temperature, dryer dew-point temperature, collector fan event and exhaust fan event to record when the fans came on or went off. The time of loading green plants and removing dryed plants were recorded manually.

The temperatures and relative humidities recorded by the hygrothermographs were used as a verification that the data collected by the 12 point recorder was correct. There was good correlation between the data gathered by the different instruments and between the data of this experiment and ambient temperatures and relative humidity data taken by the weather station at the NSTL.

d. A light sensitive switch in the solar collector fan circuit permits fan operation only during daylight hours. A humidistat overrides all fans to keep them off during conditions of high humidity.

The data was collected from August 1, 1976, to October 1976.

4. Loading and Unloading - The plants were harvested from the surface of the water using a pusher boat and a five foot wide conveyer which deposited the plants in a conventional agricultural manure spreader with side boards added to hold approximately one ton of wet plants.

The spreader, powered by a tractor, then deposited the load directly on the grating and was repeated until the dryer floor was covered to a desired thickness of approximately 12 inches.

Table 1. Accumulated Air Heat Calculations

	August	September	Oct. (1-15)
Average ΔT Across Solar Collectors	10.6	11.6	13.6
Total Number of Hours Energy Collected	*223	134	91
Average Hours per Day Energy Collected	*8.9	7.05	7.57
Number of Days Energy Collected	*25	19	12
Average Total Insolation btu/ft^2 Day Available	2144	2264	2252
Average Total Energy Collected btu/ft^2 Day	1080	936	1178
Collector Effort	0.5	0.41	0.52
Average Day Length Sunrise to Sunset	13.3	12.3	10.7
Solar Energy Collected per Day btu X 10^6	1.244	1.078	1.357
Commercial Electricity Used per Day btu X 10^6	0.251	0.201	0.196
Ratio Solar to Commercial Power	4.96	5.36	6.92

* During the first 20 days of August the fans were manually controlled from 0800 to 1630 without the humidistat. It took several days to get the humidistat adjusted. Therefore, this number is not truly comparable to September and October numbers.

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Example Calculation

11.6 = average Δt across solar collectors °F

8 = average Δt between house temperature and ambient temperature °F

39,000 = cfm moved through the dryer

12,000 = cfm moved across the collectors

$$\left(39{,}000\ \frac{ft^3}{min}\right)\left(.0763\ \frac{lb}{ft^3}\right)\left(0.24\ \frac{btu}{lb\ °F}\right)\ (8°F)\ \left(60\ \frac{min}{hr}\right) = 342{,}800\ btu/hr.$$

$$\left(12{,}000\ \frac{ft^3}{min}\right)\left(.0763\ \frac{lb}{ft^3}\right)\left(0.24\ \frac{btu}{lb\ °F}\right)\ (11.6°F)\ \left(60\ \frac{min}{hr}\right) = 152{,}942\ btu/hr$$

342,800 btu/hr. total required to raise air temperature in house
-152,942 btu/hr. total heat brought into house from collectors
189,858 btu/hr. total solar energy entering through roof and walls of house

$$(20)\ (.85y) = 17y \text{ hence } \frac{(17)\ (704)}{2000} = \frac{11{,}968}{2000} = 5.98T$$

then $[(5.98)\ (2000)] - 704 = 11{,}264$ lbs H_2O removed

then $\frac{(11{,}264)\ (970)}{10^6} = 10.93$ million btu's required

then $\left(6.91\ \frac{hw\ hr}{hr\ or\ fan\ op}\right)$ (53 hrs of fan op) $\left(3415\ \frac{btu}{kw\ hr}\right)$

= 1,250,000 btu or 1.25 million btu's electrical energy

then (10.93) - (1.25) = 9.68 million btu's solar energy

and $\frac{9.68}{10.93} = 89$ percent free energy from the sun

DISCUSSION

It becomes quickly obvious that:

1. The Solar collector panels operating at approximately 50 percent efficiency is very attractive based on the simple design using only standard materials (lumber, glass, sheet metal and paint).